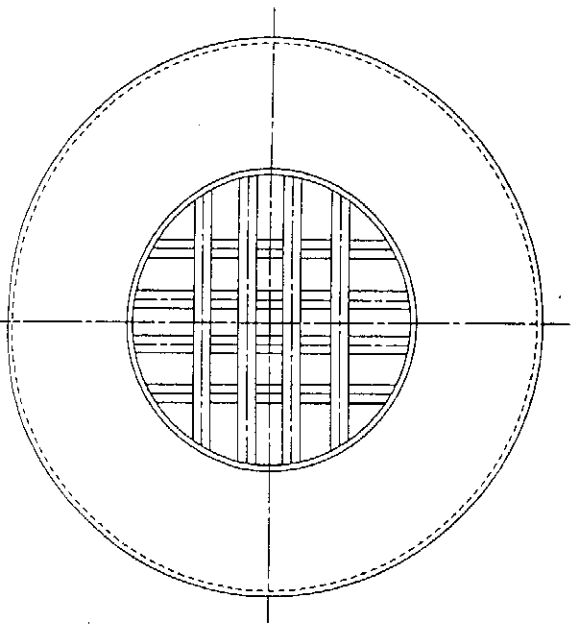
Fermilab RF Cavity Efforts

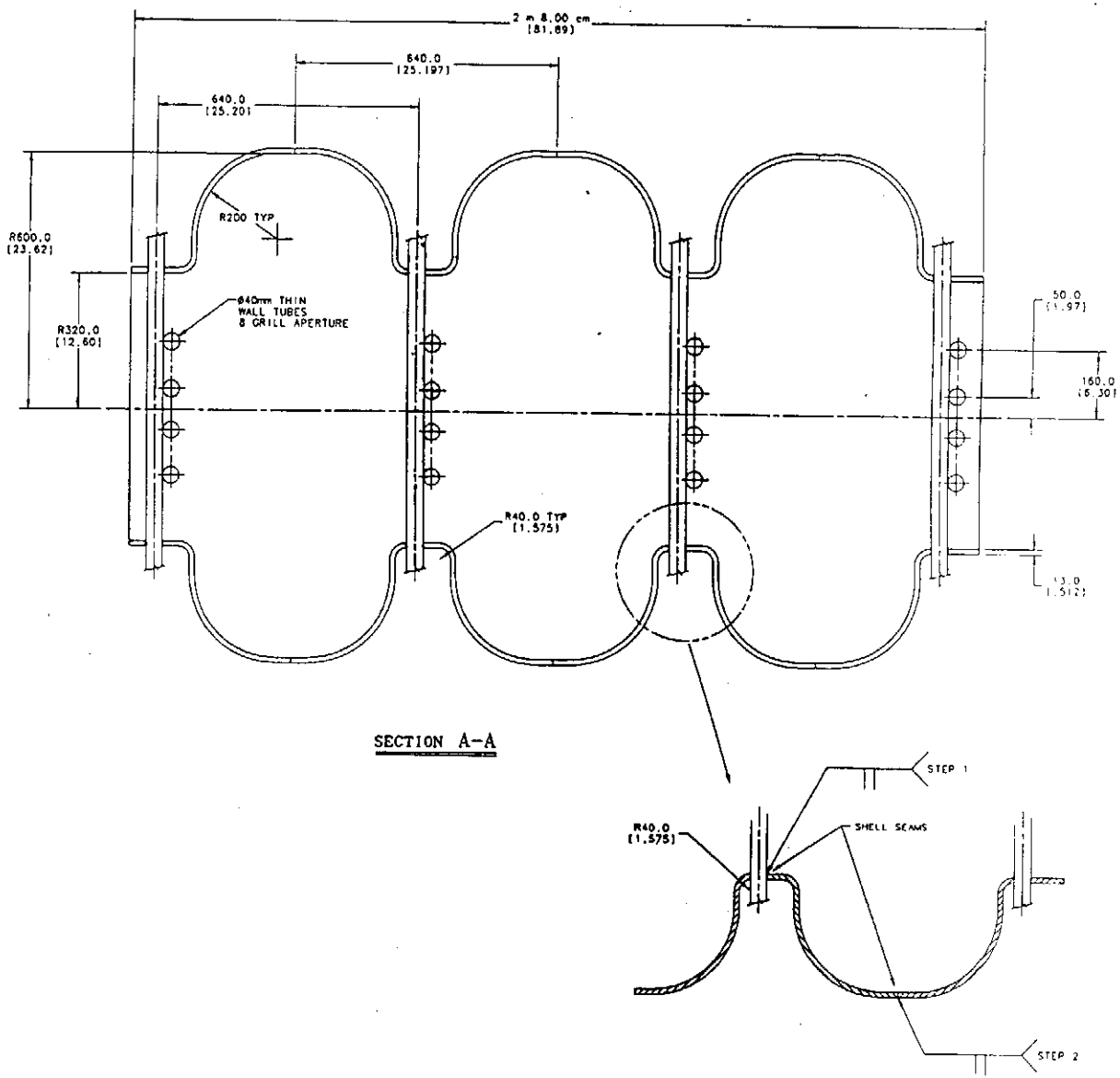
Thomas Jurgens
2000.February.15

Neutrino Source Based on a Muon Storage Ring
Feasibility Study Meeting

201 MHz Cavity

- Tube Gridded Aperture
- Spun Form
- π phase advance





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MAFIA

FRAME: 11 14/02/10 - 16:13:39 ERSION[V4.020]

./E3C.DRC

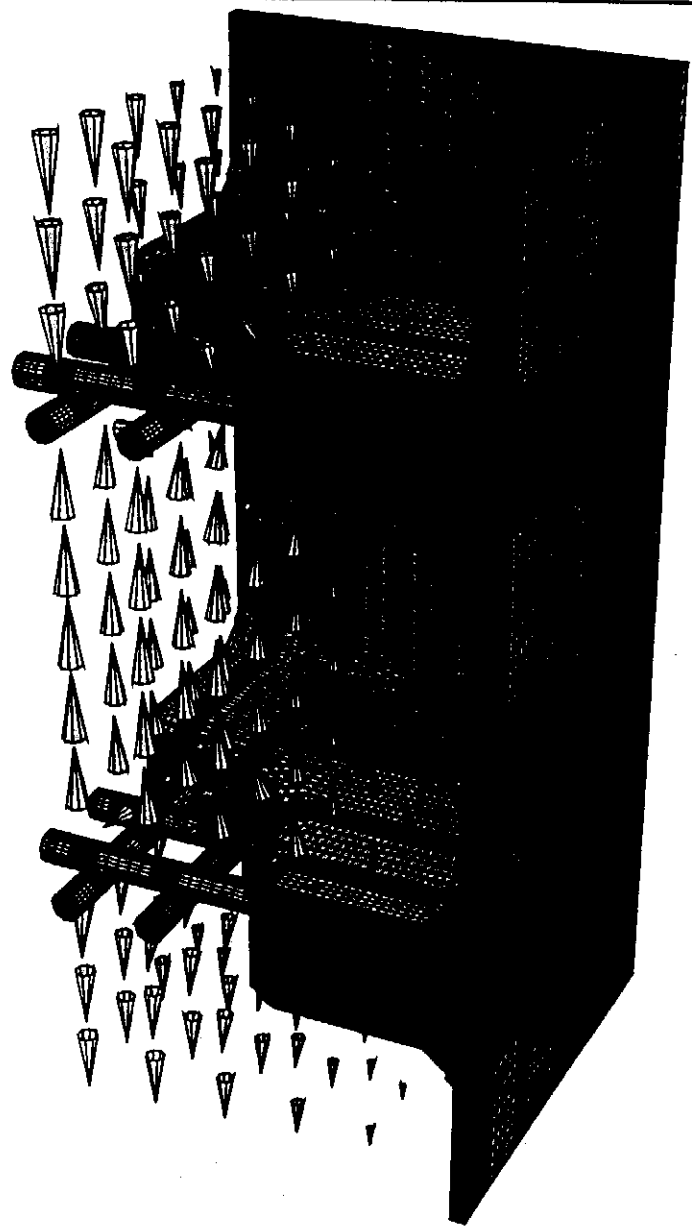
FREQUENCY/HZ	2.0431742400000E+08
MAXIMUM ERROR OF CURLCURL-E	7.1882396936417E-02
MEAN ERROR OF CURLCURL-E	1.8589434912428E-03
MAXIMUM ERROR OF DIVERGENCE-D	4.0724373207013E-07

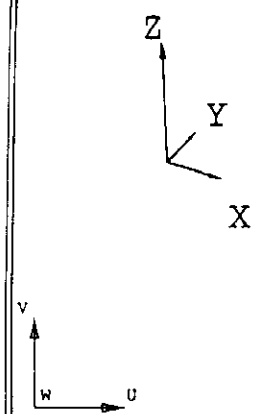
201.25 MHZ TEST CAVITY
ONE EIGHTH OF THE STRUCTURE IS MODELED IN XYZ, E-MODE
PI MODE; OPERATING FREQUENCY:201.25 MHZ
TIME HARMONIC ELECTRIC FIELD IN V/M

#3DARROW

COORDINATES/M
FULL RANGE / WINDOW
X[0.0000, 0.61250]
[0.0000, 0.61250]
Y[0.0000, 0.61250]
[0.0000, 0.61250]
Z[0.0000, 1.2960]
[0.0000, 1.2960]

SYMBOL: E_6
TIME.....: 0.
MAX. ARROW.: 3.503E+00
INTERPOLATE- 1
LOGSCALE...- 0.
MATERIALS: 1,2,3,4, 6,
8,9.





π mode aperture = 64 cm diameter

201 MHz Cavity Dispersion

Mode	0	π/2	π
Frequency (MHz)	205.045	204.666	204.317

Thomas Jurgens

RF Cavity Parameters

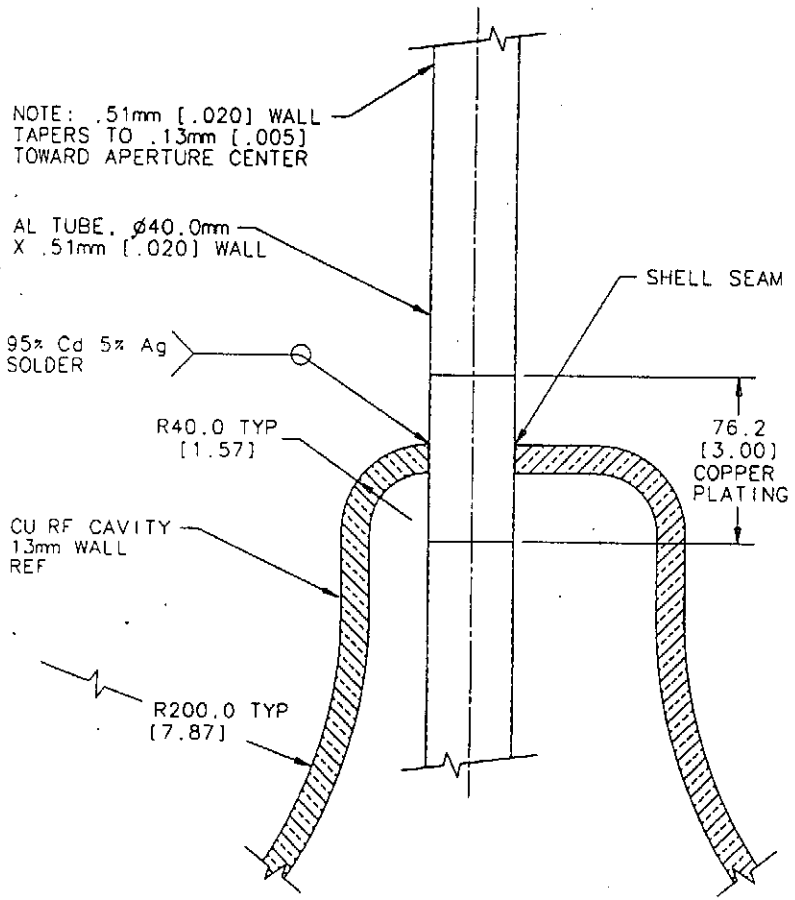
Channel Length 2.5 m.
Beam Aperture (Diameter) 64 cm.
Pi phase advance per cell

The data in this table may be revised occasionally. Please check back often.

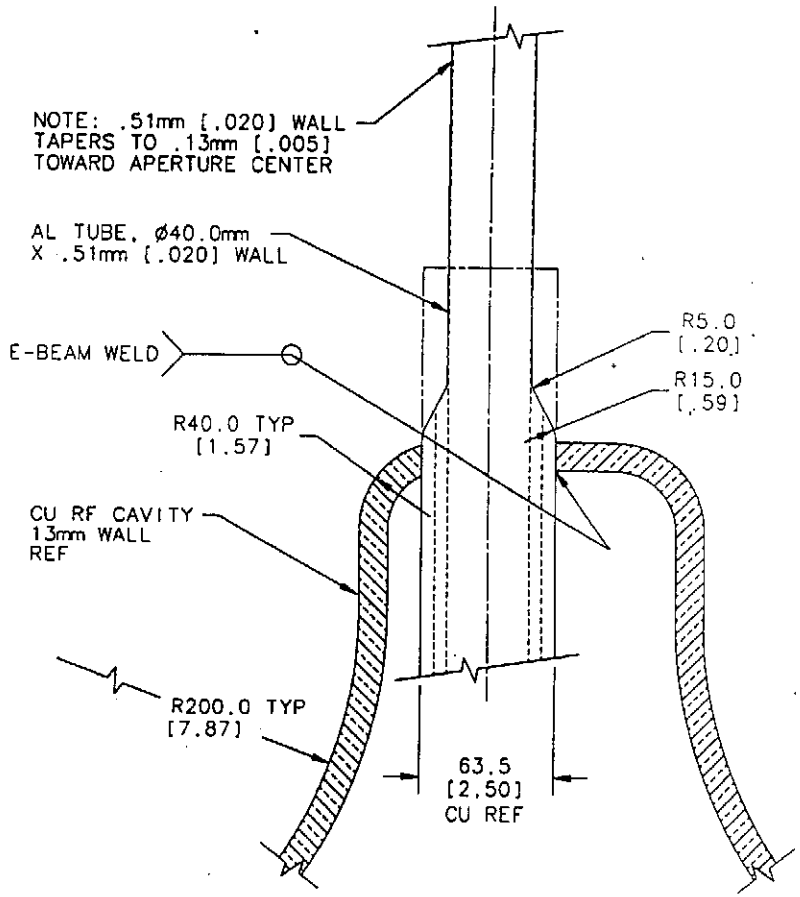
PRELIMINARY DATA

Parameter	Value
Beta	0.87 (p_z=187 MeV/c)
Energy Loss Factor in Hydrogen	0.303 MeV/cm
Frequency	201.25 MHz
Accelerating Phase Angle	sin(25 °)
Hydrogen Absorber Length	30 cm
Average Accelerating Gradient	11.3 MV/m
Peak Accelerating Field	16.4 MV/m
Peak Surface Field	28.0 MV/m
Kilpatrick Limit	14.8 MV/m
Cavity Type	Open cell with crossed tubes over aperture
Number of Cells per Cavity	3
Cavity Dimensions	The internal radius is 0.600m, determined by MAFIA calculations. The internal cell length, lambda*beta/2, is 0.648m. The length of an accelerating section is 1.944m. Three coaxial lines feed the cavities from room temperature (warm bore) ports, 0.17m diameter, passing through the magnet cryostat.
Impedance	35 Mohm/m (no transit time correction, $Z=V^2/(P*d)$)
Shunt Impedance	ZT^2=16.68 Mohm/m, 10.81 Mohm per cell
Transit Time Factor T	0.69
Peak Voltage per Cell	10.6 MV
Voltage per cell	7.3 MV
Q_o	69,000

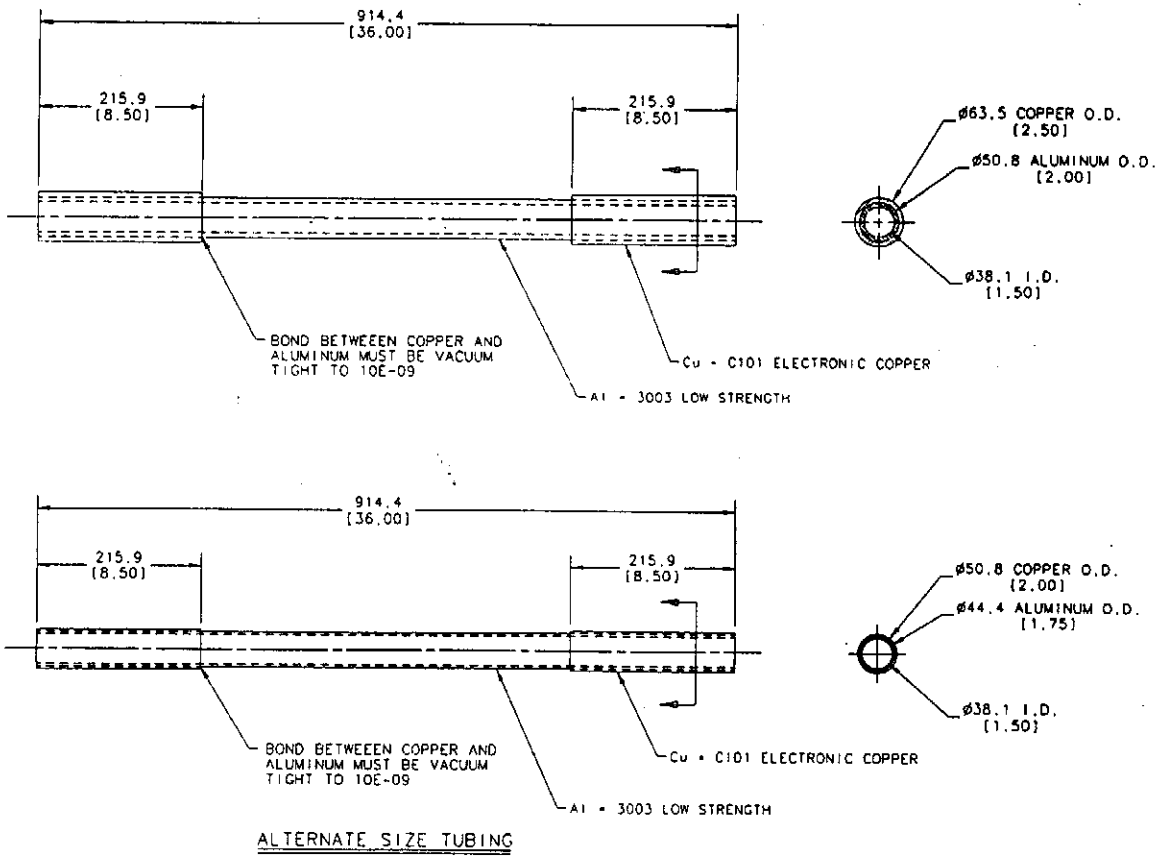
Fill Time	52 microseconds, critically coupled (one fill time)
Bunch Length (sigma)	10 cm
Number of Bunches in Train	30
Bunch Train Length	150 ns
RF pulse	156 microseconds
Duty Cycle	2.34×10^{-3}
Peak Power Requirement	$(16.4 \times 10^6)^2 / 35 \times 10^6 = 7.68$ MW/m
Peak Power per Cell	(7.68/3)x1.944 = 5.0 MW
Average Power per Cell	5.0 MW x 2.34×10^{-3} = 11.6 kW
Window Type	4 cm diameter Al crossed tubes
Average Power On Tubes	130 W (worst tube)
Conductivity Al/Cu	3.72×10^7 / 5.8×10^7 S/m
Skin Depth	4.6 microns (Cu), 5.8 microns (Al)

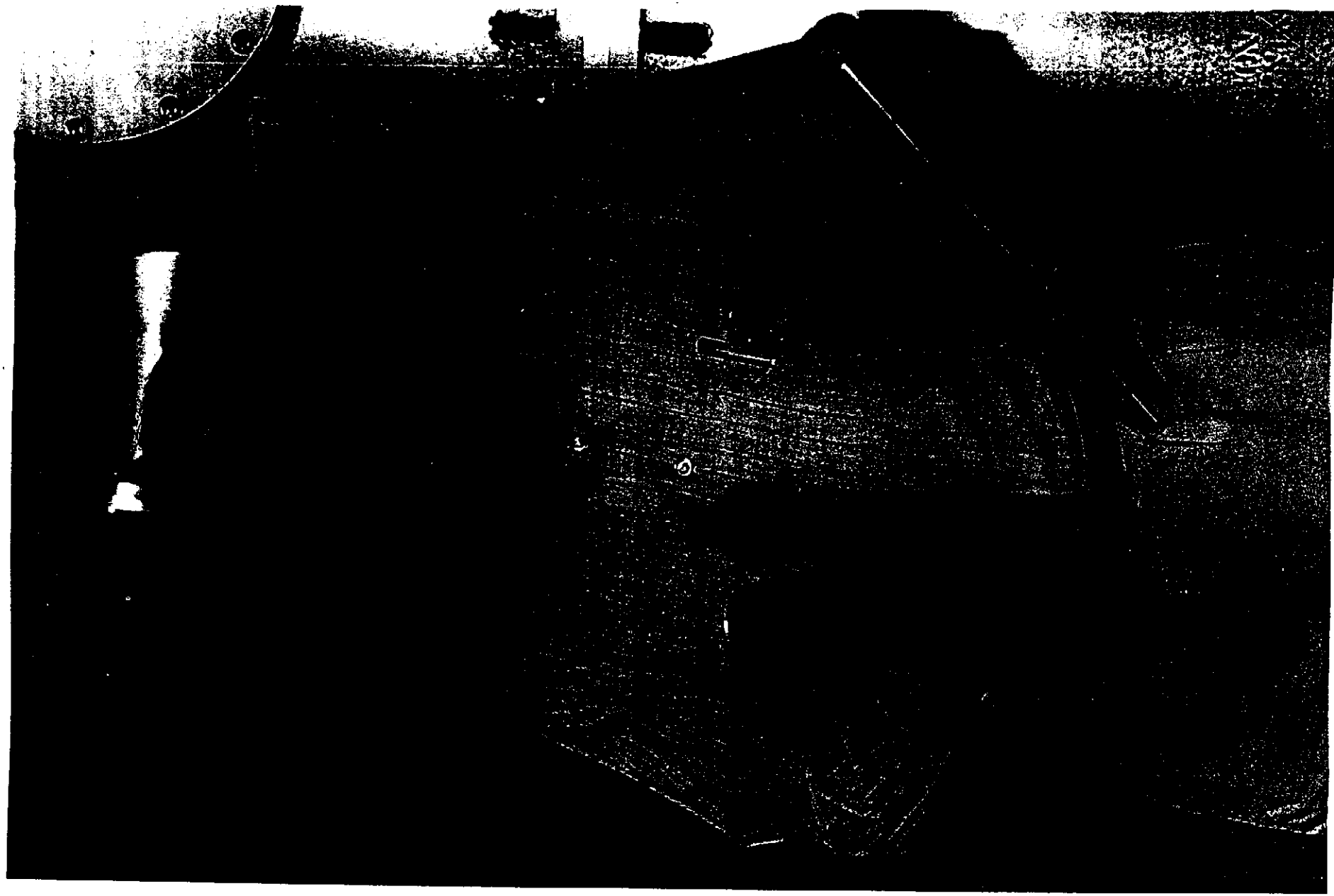


TUBE DETAIL
COPPER PLATING
SCALE: 1:2



TUBE DETAIL
COPPER PLATING
SCALE: 1:2


914.4
[36.00]
215.9
[8.50]
215.9
[8.50]
ø63.5 COPPER O.D.
[2.50]
ø50.8 ALUMINUM O.D.
[2.00]
ø38.1 I.D.
[1.50]
BOND BETWEEEN COPPER AND
ALUMINUM MUST BE VACUUM
TIGHT TO 10E-09
Cu - C101 ELECTRONIC COPPER
Al - 3003 LOW STRENGTH
914.4
[36.00]
215.9
[8.50]
215.9
[8.50]
ø50.8 COPPER O.D.
[2.00]
ø44.4 ALUMINUM O.D.
[1.75]
ø38.1 I.D.
[1.50]
BOND BETWEEEN COPPER AND
ALUMINUM MUST BE VACUUM
TIGHT TO 10E-09
Cu - C101 ELECTRONIC COPPER
Al - 3003 LOW STRENGTH
ALTERNATE SIZE TUBING



RF Cavity Parameters

Channel Length 1.1 m.
Beam Aperture (Diameter) 38 cm.
2Pi/3 phase advance per cell

The data in this table may be revised occasionally. Please check back often.

PRELIMINARY DATA

Parameter	Value
Beta	0.87 (p_z=187 MeV/c)
Energy Loss Factor in Hydrogen	0.303 MeV/cm
Frequency	201.25 MHz
Accelerating Phase Angle	sin(25 °)
Hydrogen Absorber Length	13.5 cm
Average Accelerating Gradient	11.2 MV/m
Peak Accelerating Field	13.25 MV/m
Peak Surface Field	22.53 MV/m
Kilpatrick Limit	14.8 MV/m
Cavity Type	Open cell with crossed tubes over aperture
Number of Cells per Cavity	2
Cavity Dimensions	The internal radius is 0.600m, determined by MAFIA calculations. The internal cell length, lambda*beta/3, is 0.432m. The length of an accelerating section is 0.864m. Two coaxial lines feed the cavities from room temperature (warm bore) ports, 0.17m diameter, passing through the magnet cryostat.
Impedance	25.5 Mohm/m (no transit time correction, $Z=V^2/(P*d)$)
Shunt Impedance	ZT^2=18.2 Mohm/m, 7.86 Mohm per cell
Transit Time Factor T	0.845
Peak Voltage per Cell	5.7 MV
Voltage per cell	4.8 MV
Q_o	47,500

Fill Time	38 microseconds, critically coupled (one fill time)
Bunch Length (sigma)	10 cm
Number of Bunches in Train	30
Bunch Train Length	150 ns
RF pulse	114 microseconds
Duty Cycle	2.34×10^{-3}
Peak Power Requirement	6.8 MW/m
Peak Power per Cell	2.9 MW
Average Power per Cell	6.7 kW
Window Type	4 cm diameter Al crossed tubes
Average Power On Tubes	25 W (worst tube)
Conductivity Al/Cu	3.72×10^{7} / 5.8×10^{7} S/m
Skin Depth	4.6 microns (Cu), 5.8 microns (Al)

Back To Neutrino Factory Main Page

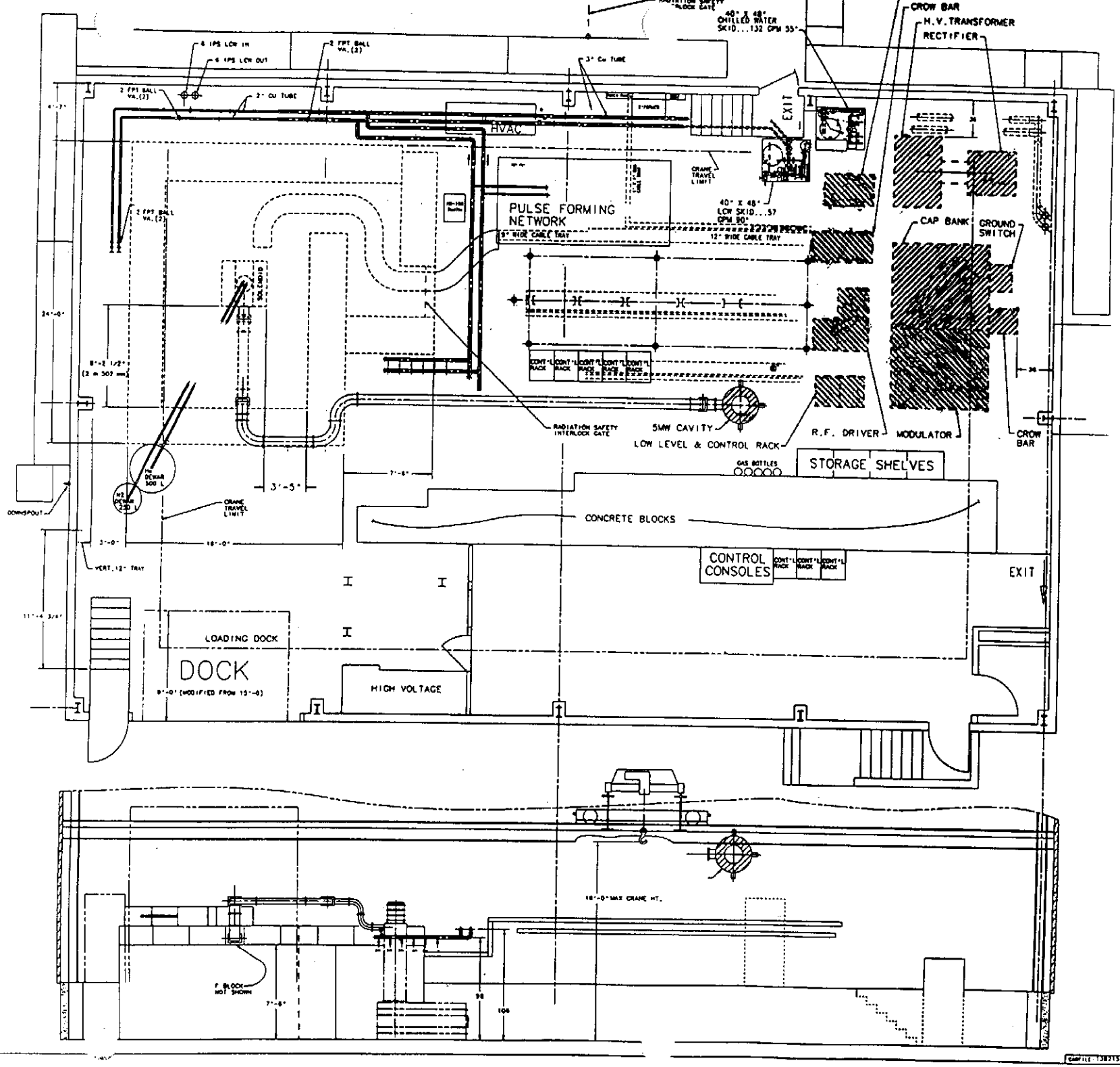
Suggestions? Contact...

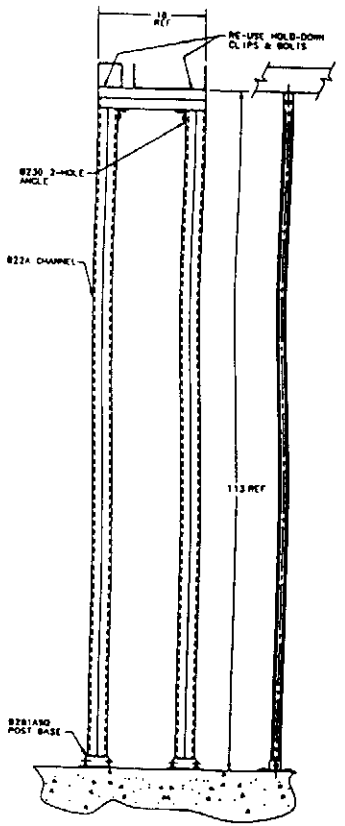
- *Thomas G. Jurgens <jurgenst@fnal.gov>*

Last Updated: 9 December 1999

Comparison of Open and Gridded Cavities to Pillbox

Cavity Type	Radius of Aperture, cm	Mode	Zo, Mohm/m	(2 cell) RF Power,	Peak Field, MV/m
Pillbox	19	Pi/2	20	2.6	7.2 on axis
4 Rod Open	19	2Pi/3	25	1.3	8.9 on tubes
Pillbox	19	2Pi/3	27	1.2	5.8 on axis





TYP. CABLE TRAY FLOOR SUPPORT
1/8 SCALE

INSTALL THESE SUPPORTS AS REQUIRED BEFORE REMOVING EXISTING RACK-BASED SUPPORTS

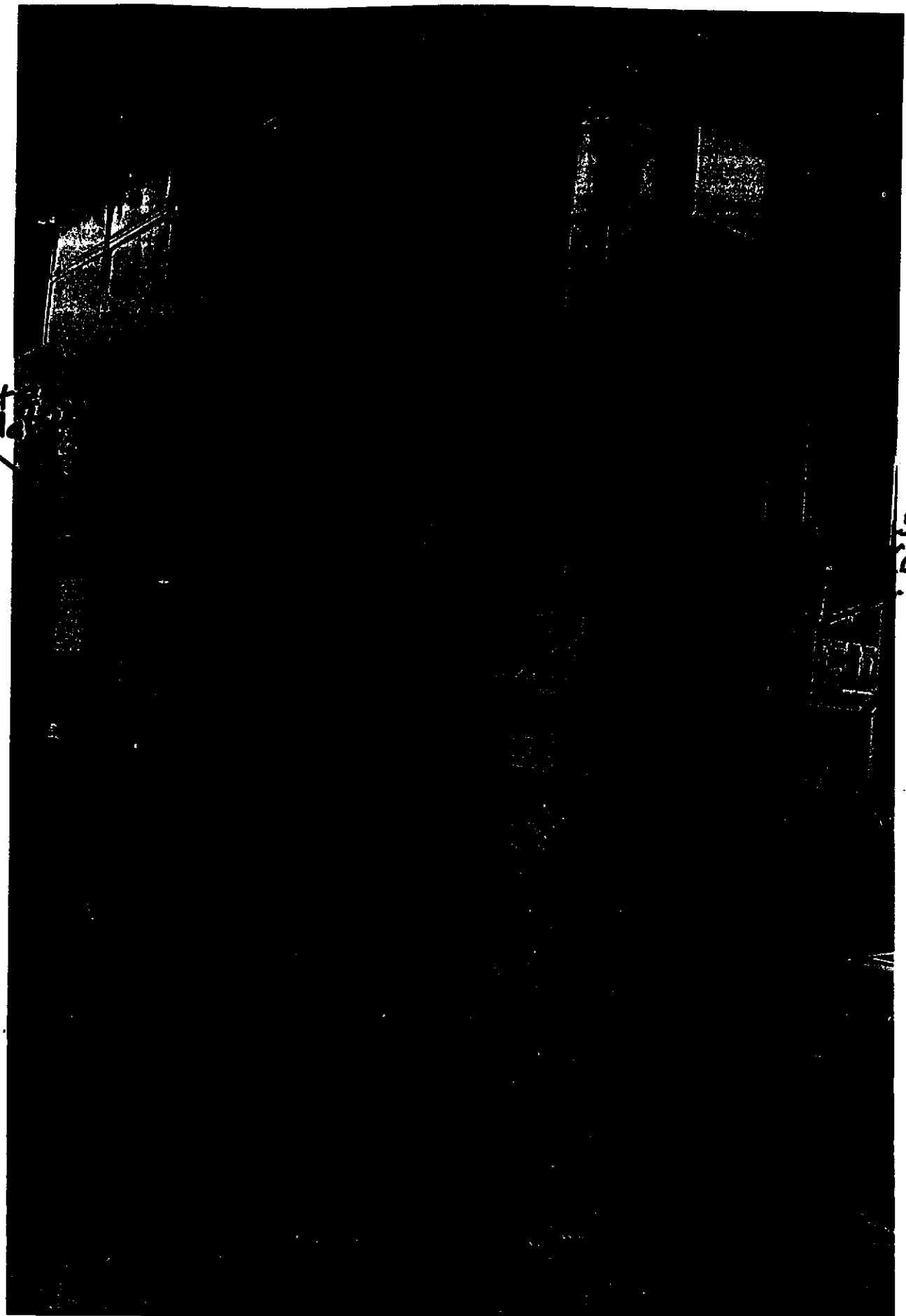
200 MHz 5MW test Stand in Lab G

PARTS LIST

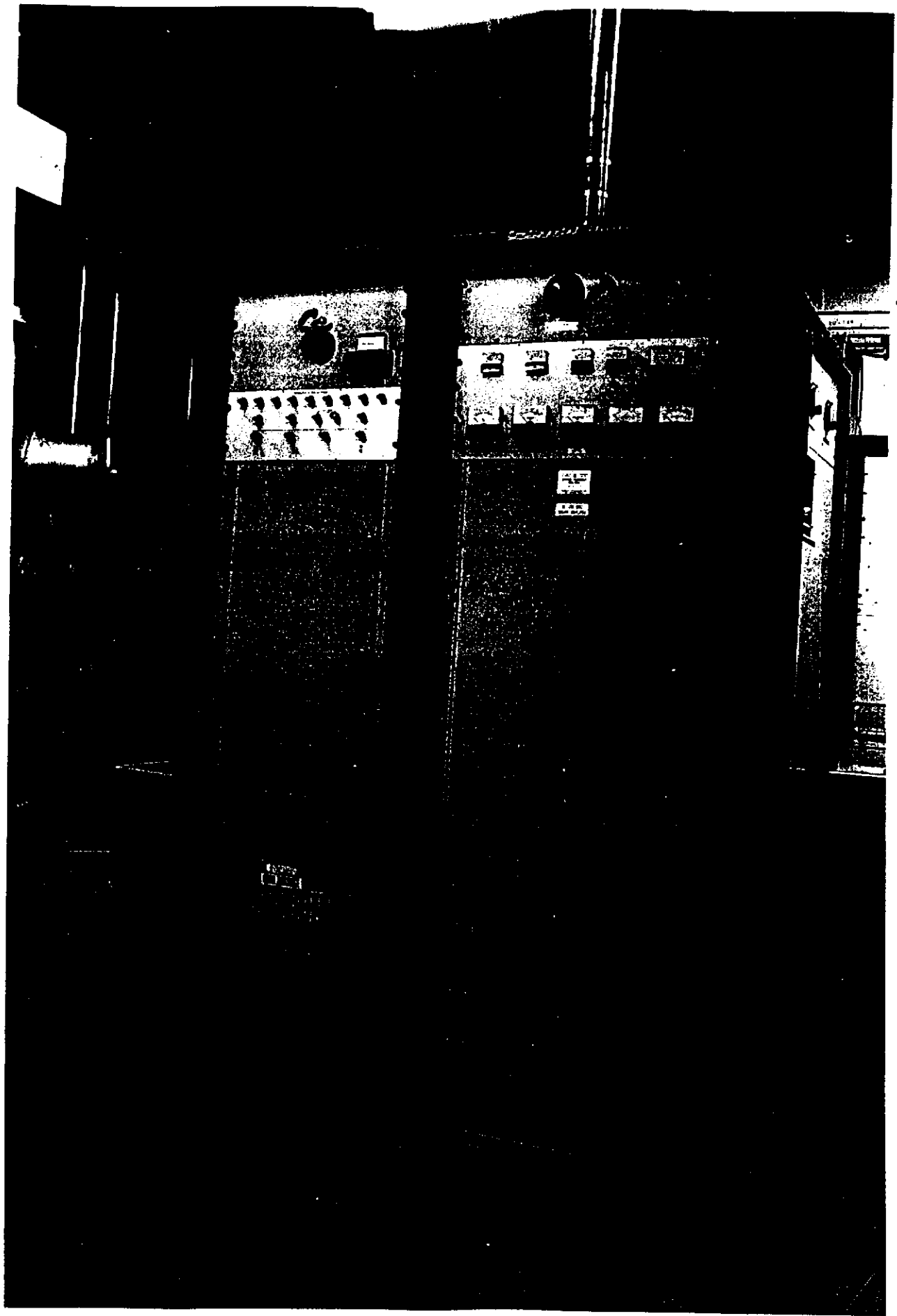
FERMI NATIONAL ACCELERATOR LABORATORY
UNITED STATES DEPARTMENT OF ENERGY

MUON COOLING EXP.
200 MHz & 800 MHz LAB G
EQUIPMENT LAYOUT AND CABLE TRAY SUPPORT

2130-000-ME-138215



Fermilab Photograph 99-1123-1D



200MHz
250kW
Driver

Fermilab Photograph 99-1123-2

Cavity Characteristics

- Larger Aperture Than Be Window
- Permits Window Cooling
- Coupling Between Cavities ~ 0.1%
- Tubes Can Be Tapered
- Attachment And Construction of Grid
- Tunable By Wall Displacement
- Cavities Are Independently Excited

R & D Needs

- Grid Construction
- Spin Form Cavity Construction
- Integration of Grid and Cavity
- Tuning Methods
- High Power Performance